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April 21, 1999
Assistant Commissioner for Patents
Washington, DC 20231

EXPRESS MAIL NO. EE776240186US

TRANSMITTAL LETTER SMALL ENTITY APPLICATION

Dear Sir:

Please find enclosed a patent application and formal papers as follows:

Applicant(s): Howard B. Sosin

Title: SYSTEM FOR OPTIMIZATION OF GOLF CLUBS

No. Pages Specification: 16; No. Pages Claim 7 No. Pages Drawings 2; No. Pages Abstract 1:

Basic Filing Fee (Small Entity):

\$380.00

Additional Fees:

Total Number of Claims in excess of 20 times \$9: 25 x \$9

\$225.00

Number of Independent Claims minus 3 times \$39: x \$39

\$117.00

Multiple Dependent Claims (\$130):

\$

Total Filing Fee:

\$722.00

Also enclosed is: **Unexecuted** Combined Declaration and Small Entity

Enclosed please find a check in the amount of **\$722.00**.

Please charge any additional fees, and credit any overpayments, to our Deposit Account No. 03-1721.

If this application is found otherwise to be INCOMPLETE, or if at any time it appears that a TELEPHONE CONFERENCE with counsel would helpfully advance prosecution, please telephone the undersigned at any time.

Kindly acknowledge receipt of the foregoing application by returning the self-addressed postcard.

Respectfully submitted,



Elizabeth E. Nugent, Reg. No. 43,839

Applicant : Howard B. Sosin
Serial No. :
Filed : April 21, 1999
For : SYSTEM FOR OPTIMIZATION OF GOLF CLUBS

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
37 CFR 1.9(f) and 1.27(b)
INDEPENDENT INVENTOR

As below-named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code with regard to the invention titled:

TITLE: System for Optimization of Golf Clubs
by:

INVENTOR(S): Howard B. Sosin
described in:

- ☒ the specification filed herewith
☐ U.S. Patent Application Serial Number _____
filed _____
☐ U.S. Patent Number _____
issued _____

I have not assigned, granted, conveyed, or licensed and am under no obligation under contract or law to assign, grant, convey, or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern that would not qualify as a small business concern under 37 CFR 1.9(d) or a non-profit organization under 37 CFR 1.9(e).

Each person, concern, or organization to which I have assigned, granted, conveyed, or licensed, or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

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I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF SOLE INVENTOR: Howard B. Sosin
ADDRESS OF INVENTOR: 640 Sasco Hill Road
 Fairfield, CT 06430

SIGNATURE: _____ DATE: _____

0651240"ET55240

Sole

**APPLICATION
FOR
UNITED STATES LETTER PATENT**

TO THE ASSISTANT COMMISSIONER FOR PATENTS:

BE IT KNOWN, that I, **Howard B. Sosin** has invented certain new and useful improvements in
SYSTEM FOR OPTIMIZATION OF GOLF CLUBS of which the following is a specification:

System for Optimization of Golf Clubs

Field of the Invention

5 The present invention relates to a system for constructing a set of matched golf clubs which are optimized for a particular golfer.

Background of the Invention

10 The rules of golf allow a golfer to carry a golfer to carry a maximum of fourteen clubs: an assortment of “woods” and “irons,” and usually one “putter.” Golfers select clubs to produce shots of predetermined lengths (carry plus roll) and trajectories. Once clubs have been selected, the golfer’s goal is to swing each club in a manner that gives predictable results. It is recognized that the golfer’s job is made easier if the same (or a similar) swing works for all clubs: a “repeatable” swing. It is further recognized that a repeatable swing is facilitated by having all of the clubs “feel the same” (or similar) 15 during the swing. A set of clubs which feel the same to the golfer is said to be “matched.”

20 Club manufacturers offer a vast array of clubs for golfers to choose from. Within a set, manufacturers typically seek to match clubs (often separating woods and irons) by having the club heads have similar shape and be made of similar materials. Additionally, sets usually have uniform grips and shafts (material and flexibility) and some manufacturers allow the golfer to customize club length and/or lie.

25 In addition to matching these basic parameters, many attempts have been made to match clubs in other ways. “Swing weighting” systems generally match clubs according to their first inertial moment about an arbitrarily selected point twelve inches (“Lorythmic scale”) or fourteen inches (“Official scale”) from the butt end of the club (see, U.S. Patent Nos. 4,128,242 to Elkins, Jr. and 4,887,815 to Hughes *et al.*). Related systems have been proposed to balance the club about a point closer to the grip, *e.g.*, five inches from the butt end of the shaft (see, U.S. Patent No. 4,674,324 to Benoit). Other methods include matching the first inertial moment and/or the second inertial moment

(see, U.S. Patent No. 4,415,156 to Jorgensen), the radius of gyration (see, U.S. Patent Nos. 4,674,324 to Benoit and 5,277,059 to Chastonay), or the vibrational frequencies (see, U.S. Patent Nos. 4,555,112 to Masghati and 5,722,899 to Cheng) over the set of clubs.

With the exception of one system that seeks to equalize the dynamic moment of inertia of the club including the moment of inertia of the golfer's arms (see, U.S. Patent No. 5,769,733 to Williams, *et al.*), all currently known club matching systems focus on matching clubs to a selected mathematical standard with no attempt to incorporate the physical and swing characteristics of a particular golfer. Since golfers differ in many ways not addressed by mathematical standards, it is not surprising that it remains an elusive goal for a golfer to obtain a set of clubs which truly provide him with a uniform swing feel. An improved method of selecting and matching clubs to optimize a golfer's game is needed.

Summary of the Invention

The present invention provides a method of designing a matched set of golf clubs which takes into account both objective parameters which control the motion of the ball in response to an impact from a club head, and subjective parameters related to individual preferences in “feel” and idiosyncracies of a particular golfer’s swing.

In one aspect, the invention comprises a method of designing a golf club, comprising determining relationships relating tempo (how fast the golfer swings) and perceived force (how much force is applied along the shaft) to club length and club head mass for a particular golfer. Two parameters are selected from the following group of three: target distance, club length (and shaft flexibility), and preferred trajectory for the ball, and then these parameters are used with the tempo and perceived force functions to determine the third parameter and the club head mass for the golf club design. Tempo may be measured by the speed of the golfer's hands at the moment of impact, and perceived force by the centripetal force along the shaft of the club at the moment of impact. In order to determine these values, an effective arm length may be determined, for example by measuring the actual arm length of the golfer, or the distance from the

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Perceived force may be determined by the centripetal force applied along the shaft at impact, and the tempo may be determined by the speed of the golfer's hands at impact. Preferably, clubs have selected functional relationships for both tempo and perceived force. Clubs may further have optimized lean angle as described in U.S. Patent Application 08/248,515. Clubs may be constructed, for example, using a CAD/CAM system.

As it is used herein, the term "club length" means the length of a club as measured from the butt end of the shaft to the center of mass of the club head.

Brief Description of the Drawing

Preferred embodiments of the invention are described with reference to the single figure of the drawing, which

Figure 1 plots of club head mass as a function of club length for three sets of clubs according to the invention; and

Figure 2 is a schematic view of a club weighted to adjust the radius of gyration according to the invention.

Detailed Description

A logical starting point (although not the only possible starting point) in the design of a set of clubs is for the golfer to specify target distances (carry and roll) and trajectories for up to 13 clubs (leaving one space in the set for a putter) that he could expect to achieve with reasonable consistency with a full swing given his physical parameters and swing characteristics. Thus, for example, a reasonably advanced golfer might specify target distances of 250, 225, 200, 187.5, 175, 162.5, 150, 137.5, 125, 112.5, 100, 87.5, and 75 yards, respectively. He could also specify desired trajectories. In the preferred embodiments of the invention, desired trajectory is fully described either by the design loft of the club head (the manufacturer's intended loft), or by the effective loft of the club head (the actual loft at impact) each as more fully defined in copending

and commonly assigned U.S. Patent application 09/248,515, filed February 8, 1999, which is incorporated herein by reference.

For a particular type of golf ball, each target distance can be achieved by an infinite number of combinations of club head masses and lofts, club lengths and shaft flexibilities, and swing speeds. A table (hereinafter, the Table) could be constructed that, to any degree of fineness desired, shows how varying these parameters varies the distance (and trajectory) achieved. An automatic ball striking machine could be used to construct such a Table. Alternatively, the Table could be constructed by carefully observing the results of golfers hitting balls with various clubs. In yet another embodiment, the values in the Table might be determined by analytical calculations.

A golfer may wish to base his target distances and trajectories off the longest distance he can consistently achieve (typically with a driver). Conventional wisdom suggests that driving distance is relatively insensitive to club head weight for most golfers (see, for example, Cochran and Stobbs, *Search for the Perfect Swing*, Triumph Books, Chicago, 1968). Therefore, club head weight can be held at a suitable constant level (e.g., 200 g) while optimizing club length (and shaft flex) and club head loft. Alternatively, the player may be allowed to vary club head weight in the following procedure in order to determine a maximum driving distance.

Using drivers of varying length (and possibly also of varying shaft flexibility), the length which allows the golfer to generate the maximum club head speed (where, *ceteris paribus*, speed is a surrogate for impact force) can be determined using various known devices for the measurement of club head speed at impact. Once the maximum consistently achievable club head speed is known, the other parameters (e.g., loft, club head weight, *etc.*) can be varied (using analytical or empirical methods, or by having a golfer attempt to swing the club at a constant speed) to determine the combination of parameters that achieves the golfer's maximum driving distance. Knowing his maximum driving distance would allow a golfer to choose useful target distances for the remaining clubs.

The present invention suggests that two parameters should be used to select amongst possible clubs for each desired target distance and trajectory: the force the golfer

wants to feel at the time he strikes the ball with the club (his “perceived force” function), and how fast he wants to swing the club (his “tempo” function). The invention further teaches that a golfer will be better able to achieve a repeatable swing (*i.e.*, generate the desired perceived force at the desired tempo over and over again) if the variation in how long different clubs feel during the swing (the “perceived length” function) is reduced relative to prior art clubs. In the preferred embodiments of the invention, perceived force is measured by the centripetal force at the point of impact of the club head with the ball, and tempo is measured by the speed of the golfer’s hands (also at the point of impact). In other preferred embodiments of the invention, perceived length is measured by the radius of gyration calculated around a golfer’s personal center (described below).

In one preferred embodiment of the invention, tempo and perceived force are maintained as constants over the set of clubs. This embodiment has been found to lead to club heads that are lighter than those usual in the art. In another preferred embodiment, tempo increases linearly with club length plus arm length over the set of clubs, while perceived force remains constant. The motivation for this preferred embodiment comes from the fact that many golfers swing their longer clubs (for longer shots) with more abandon (*i.e.*, faster) than their shorter clubs, and thus prefer to feel a faster hand speed for the longer clubs, while retaining the same feeling of force at impact. This embodiment has been found to lead to club heads that are heavier than those usual in the art. An embodiment wherein tempo is constant and centripetal force increases linearly with length produces constant weight club heads; an embodiment wherein tempo is constant and centripetal force increases faster than linearly produces club heads that increase in weight as the club length increases. Finally, an embodiment wherein tempo increases with the square root of club length plus arm length, while perceived force remains constant, maintains the ability of the golfer to swing longer clubs with greater abandon, and produces club heads with weights similar to those of prior art clubs.

The first two preferred embodiments described in the paragraph above can be considered to be zero-parameter and one-parameter models of a golfer’s preferred swing characteristics. Higher-order models can also be used, *e.g.*, polynomial or power-law models. The model chosen will depend upon the preferences of the individual golfer, and

may be determined subjectively or analytically, for example, by video analysis of the golfer's swing to determine a preferred relationship between hand speed, centripetal force, club length, and club head mass. The number of parameters should be small enough to actually constrain the club selection.

5 Regardless of the swing technique used by the golfer, at impact the left (leading) arm and the shaft of the club typically will be virtually in line and moving together like an extended shaft. This fact allows determination of the speed of the golfer's hand at impact (the tempo) if his "effective" arm length is known. (The effective arm length may be approximated by the actual length of the golfer's arms, or by a length measured from the top of the sternum to the hands when the club is at address position, or by other appropriate measurements of the golfer's body). That is, knowing the impact speed of two club heads (e.g., the driver and another club), the lengths of the clubs and the golfer's effective arm length allows the calculation of hand speed and centripetal force for each club at impact, using the following equations:

$$15 \quad v_{hand}(driver) = v_{driverhead} \frac{\ell_{arm}}{\ell_{driver} + \ell_{arm}} \quad (1)$$

$$v_{hand}(club) = v_{clubhead} \frac{\ell_{arm}}{\ell_{club} + \ell_{arm}} \quad (2)$$

$$F_{cent}(driver) = m_{driverhead} \frac{v_{driverhead}^2}{\ell_{driver} + \ell_{arm}} \quad (3)$$

$$F_{cent}(club) = m_{clubhead} \frac{v_{clubhead}^2}{\ell_{club} + \ell_{arm}} \quad (4)$$

where $v_{hand}(driver)$ and $v_{hand}(club)$ represent the speed of the hands when swinging the

driver and the second club, respectively, ℓ_{arm} , ℓ_{driver} , and ℓ_{club} represent the golfer's effective arm length and the lengths of the driver and the second club, respectively, $v_{driverhead}$ and $v_{clubhead}$ represent the velocities at impact of the driver head and the second club head, respectively, and $m_{driverhead}$ and $m_{clubhead}$ represent the masses of the driver head and the second club head, respectively. In this embodiment, centripetal force is calculated based only on the contribution due to the mass of the club head (justification for this assumption can be found, for example, in Cochran and Stobbs, *Search for the Perfect Swing*, p. 145-147, which suggests that at impact the club head can be modeled as being suspended from a length of string). More rigorous computations of centripetal force will be readily apparent to those skilled in the art.

Using the model to determine r_{tempo} and r_{force} (the ratios of hand speed and centripetal force of the two clubs), and solving for the mass of the club head (for a specified club length), we calculate

$$r_{tempo} \equiv \frac{v_{hand}(club)}{v_{hand}(driver)} = \frac{v_{clubhead}}{v_{driverhead}} \frac{\ell_{driver} + \ell_{arm}}{\ell_{club} + \ell_{arm}} \quad (5)$$

$$r_{force} \equiv \frac{F_{cent}(club)}{F_{cent}(driver)} = \frac{m_{clubhead}}{m_{driverhead}} \left(\frac{v_{clubhead}}{v_{driverhead}} \right)^2 \frac{\ell_{driver} + \ell_{arm}}{\ell_{club} + \ell_{arm}} \quad (6)$$

$$m_{clubhead} = m_{driverhead} \frac{r_{force}}{r_{tempo}^2} \left(\frac{\ell_{driver} + \ell_{arm}}{\ell_{club} + \ell_{arm}} \right) \quad (7)$$

A number of possible models for the variation of r_{tempo} and r_{force} with club length and/or club mass are contemplated. Exemplary models include linear relationships (e.g., $r_{tempo} = \ell_{club}/\ell_{driver}$ or $r_{tempo} = (\ell_{club} + \ell_{arm})/(\ell_{driver} + \ell_{arm})$), polynomial relationships (e.g., $r_{tempo} \propto (\ell_{club}/\ell_{driver})^2 + c_0 (\ell_{club}/\ell_{driver})$), and power-law relationships (e.g., $r_{tempo} = (\ell_{club}/\ell_{driver})^k$ or $r_{tempo} = (\ell_{club} + \ell_{arm}/\ell_{driver} + \ell_{arm})^k$). In particular, a square root relationship in which $r_{tempo} =$

In one preferred embodiment, perceived length is approximated by the radius of gyration (ROG). There are many plausible centers around which ROG can be measured for the purpose of matching a set of clubs, ranging from the shoulder to the elbow to the wrist to points on the shaft of the club. Previous patents (*e.g.*, U.S. Patent No. 5,277,059 to Chastonay) have used particular centers for these calculations, but in each case the center point was assumed to be the same for all golfers. The golf swing is a complex muscular action with many moving parts that must be carefully coordinated and sequenced. It is therefore not surprising that prior art, with its arbitrarily selected center of ROG, has not produced a matching system in which “matched” clubs feel substantially the same for all golfers. The present invention encompasses the realization that the center of the ROG may be a function of the swing style of a particular golfer, and that a personalized center can be measured for each golfer and used for further optimization and club matching. That is, it is believed that it is beneficial to dynamically match a set of clubs by reducing the variation in or equating their ROGs around the golfer’s personal center, and further that it is beneficial for the ROG to be quite short, as compared to that of conventional clubs. These aims can be accomplished in an embodiment of the invention as follows.

First, a golfer swings his shortest club (*e.g.*, a wedge), and mentally notes its feel. He then swings a relatively long club (*e.g.*, a driver), and weight (*e.g.*, lead tape) is added at a specified point along the shaft of the driver (usually below where the hands grip the club, relatively close to where the grip ends) until the two clubs feel as though they are the same length when swung. (The two clubs used in this test will preferably but not necessarily have been optimized for tempo and perceived force as described above). Using the magnitude of the added weight, the center of the ROG can be determined analytically, by constructing an equation for the ROG for each club about an unknown center point *X*. The ROG of the two clubs can then be set equal to solve for *X*, the golfer’s personal center. All remaining clubs in the set can then be weighted so as to equate the ROG to that of the two measured clubs. Alternatively, clubs may be weighted to equate ROG only across subsets of the clubs. A club 10 weighted to adjust the ROG is shown in **Figure 2**. The weight 12 is placed on the shaft 14 of the club 10. The origin at

the butt end of the shaft O , arbitrary position X (positive, as shown), the weight 12 position p_{weight} , and the length of the club ℓ_{club} are all shown.

It should be noted that golfers are often not used to thinking in terms of perceived length, and steps should be taken to explain the perceived length concept so that the golfer can accurately identify clubs having the same perceived length. It may be useful to have the golfer swing prior art (*i.e.*, unweighted) clubs, for example a wedge and a driver, and to identify the difference in feel as a difference in perceived length.

Additionally, the golfer could use a “baseball bat swing” test, in which the golfer (optionally blindfolded) swings clubs horizontally (to avoid hitting the ground for long clubs which nevertheless “feel” short). The baseball bat swing test may either be used directly to test clubs, or may be used to help the golfer identify the “length” perception for clubs which are subsequently swung in a more traditional manner. Alternatively, the golfer can be asked to swing clubs whose ROG variation has been reduced for typical center locations, so that the difference in feel between such modified clubs and traditional clubs can be identified.

For example, suppose the ROG optimization procedure is followed with the 36" wedge and the 48" driver described above, assuming a linear relationship for tempo. Weight is added to the driver at a point, for example, 12" from the butt end of the shaft, until the clubs are perceived as having the same length. If the added weight has a mass of 178 g, the radius of gyration about a point X inches from the end of the shaft is

$$ROG(driver) = \sqrt{\frac{m_{driverhead}(\ell_{driver} - X)^2 + m_{driverweight}(p_{weight} - X)^2}{m_{driverhead} + m_{driverweight}}} \quad (8)$$

where p_{weight} is the position of the added weight, in inches from the butt end of the shaft, and $m_{driverweight}$ is the mass of the added weight. (Those skilled in the art will note that the contributions of the shaft and grip to the ROG have been neglected in the above formulation, as have variations due to the fact that the club head and the added weight are not actually point masses. It will be apparent that the above formulae can easily be

modified to take these contributions into account). Thus, for the driver described, the ROG in terms of X is $\sqrt{((214g)(48-X)^2+(178g)(12-X)^2)/(214g+178g)}=\sqrt{X^2-63.3X+1320}$. In this simple model, the ROG of the wedge is simply the distance from X to the head of the wedge, in this case, $36'' - X$. Solving for X , we find that $X = -3$.
 5 (That is, the golfer's personal center is found at a point on his arms 3" above the butt end of the club), and the ROG of both clubs is 39". These parameters may then be used to weight all of the other clubs to match the ROG of the clubs about the golfer's personal center. (Added weights at the same point on the driver which would lead to determinations of $X=0$, $X=5$, or $X=10$ would be 187g, 208g, and 245g, respectively).

10 It is convenient but not necessary to start the process with the shortest club or to assume that the shortest club receives no weight. In one embodiment an arbitrary club is chosen and weight added until the golfer's swing speed begins to suffer. That is, weight is added which reduces the ROG to the minimum acceptable value for that golfer and that club. Then another club is chosen and weight added to it until the golfer feels that the
 15 second club has the same perceived length as the first. Once again the center point X can be analytically determined and the ROG calculated and used to calibrate other clubs. It is possible, however, that the calculations may call for the removal of weight from some clubs (which is usually infeasible). Additionally, the weights added in those
 20 embodiments of the invention which minimize ROG can be rather large, and may not be to the liking of all golfers, although it is believed that greater accuracy and consistency will be achievable once golfers become accustomed to the clubs of the invention.

It will be apparent to those skilled in the art that the weights need not all be placed at the same location on each club shaft, nor is it necessary to place only a single weight on the shaft. Similar calculations will apply, and the appropriate weight to be
 25 placed at any point or points on the shaft can be found for each club. If the golfer wishes all his clubs to have the same weight, this can generally be accommodated by solving for the position at which an appropriate weight should be added. It may be, however, that this position will not be on the shaft, in which case the design will have to be modified.

For example, ignoring possible weight differences of the grips and shafts, if the
 30 wedge has a head weight of 370 g, and the driver has a head weight of 214 g, a 156 g

weight can be placed on the driver shaft, and slid along the shaft until the clubs feel equal. (In the above case, mathematically this would occur when the weight is placed 3.28" from the butt end of the shaft). However, if the club head weight of the wedge is only 295 g, then there is no position where a 29 g weight can be placed on the driver to equate the ROGs. In this case, the ROGs may be equated by weighting both clubs. For example, if a 125 g weight is placed on the wedge at a position 27" from the butt end of the shaft (making the total weight 420 g), then a 206 g weight may be placed 1.7" from the butt end of the shaft of the driver to give both clubs an ROG of 36.6 and a total weight of 420 g (still using the personal center of $X=-3$).

In some cases, it may not be possible to equalize ROG over the entire set without the individual clubs becoming unacceptably heavy. In these cases, the ROG may be equalized for subsets of the clubs or may be made to vary in a predictable way (*e.g.*, linearly) over the set, so as to at least reduce the variation of the ROG over the set (or a subset) of clubs. "Reduced variation" in ROG, as that phrase is used herein, means a variation in ROG less than that of a set of clubs having the same club head masses and club lengths, but having no additional weights placed on the shafts.

The measurement techniques described for measurement of the ROG may also have utility in determining the "effective arm length" used in the optimization of club lengths, head weights, and lofts. The perceived center may or may not be the same for the ROG and for the centripetal force, but similar techniques involving holding all parameters but one constant and finding the closest match to a known club may be used.

It will be seen that the reduction and matching process for ROG does not change the head weight or length of the club. It can therefore easily be combined with the optimization techniques for matching tempo and perceived force described above as well as adjustments to equate design and effective loft, as described in copending and commonly assigned U.S. Patent Application No. 09/248,515.

Additional weights could be used to match the first and/or second inertial moments, either about the same center as that measured for the ROG or about a different center measured by similar methods.

The methods of the invention provide a great deal of data on optimization of golf clubs for a particular user. Given the personalized nature of the data, it may be difficult or impossible to find commercially available club heads in the style preferred by the golfer which satisfy some or all of the criteria of the invention (possibly including the criteria set forth in U.S. Patent Application No. 09/248,515). It may therefore be desirable to make club heads from scratch, and to incorporate these heads into golf clubs having desired club lengths, shaft flexibilities, grips, added weights, etc. For example, a club head can be modeled using a computer-aided design (CAD) system. The basic input to the system would be the golfer's preferred club head design, which he could either specify or choose from options already in the system. The appropriate lie, loft, head mass, lean angle (see U.S. Patent Application No. 09/248,515), and any other parameters would then be determined, and the basic design modified accordingly. (If necessary, heads may be hollow and/or made of composites in order to tailor the mass). A computer-assisted manufacturing (CAM) system can then be used to make the designed head, which may be made in multiple parts if necessary. Suitable CAM systems are commercially available which use investment casting, sand casting, electrochemical machining, electrical discharge machining, computer-controlled conventional machining systems, or other methods of forming one-of-a-kind metal items. Depending on the accuracy of the method used and the level of detail in the design, additional post-processing machining, etching, or polishing may be necessary. This method allows construction of a truly unique set of clubs, optimized for a single golfer.

Example

Table 1 shows the specification for a set of clubs optimized for the inventor. The inventor is 5'8" tall, and has an arm length of 33". The location of his personal center for ROG calculations has been determined to be 7.567" below the butt end of the shaft. His club specifications, all calculated according to the invention (*i.e.*, constant centripetal force and hand speed increasing with the square root of club length plus arm length), are as follows:

Club Length (inches)	Clubhead Weight (grams)	Club Type	Weight at 10" from shaft end (grams)	ROG (inches from X)	Target Distance (yards)
48	214	driver	220	28.44	250
46	225	3-wood	187	28.45	225
44	237	5-wood	153	28.44	200
42	250	4-iron	117	28.45	187.5
41½	254	5-iron	105	28.43	175
40⅔	259	6-iron	93	28.42	162.5
40	263	7-iron	80	28.43	150
39½	268	8-iron	67	28.43	137.5
38⅔	273	9-iron	54	28.43	125
38	279	wedge	41	28.43	112.5
37½	284	pitching wedge	27	28.45	100
36⅔	289	sand wedge	14	28.42	87.5
36	295	lob wedge	0	28.43	75

Table 1

Figure 3 plots the club lengths and club head masses specified in **Table 1**, and compares them to calculated values for a square root relationship in which $r_{tempo} = ((\ell_{club} + \ell_{arm})/(\ell_{driver} + \ell_{arm}))^{1/2}$ and $r_{force} = 1$. The shafts of these clubs are all regular flex (R) graphite shafts.

The added weights at the point 10 inches from the butt end of the shaft in the clubs described above are simply lead tape wrapped around the shaft and secured. This method of weighting the shaft has the advantage that the added mass is easily tailored and applied, but some players may prefer that some or all of the weight be added in the interior (rather than the exterior) of the shaft. It should be noted that equating the ROG over an entire set of clubs may require rather heavy weights on the longer clubs (as

demonstrated by the data of **Table 1**), which may not be practical to place solely in the shaft interior. Depending on the material used for the weights and the available space inside the shaft, embodiments of the invention placing the weights in the interior of the shaft may only be able to equate the ROG over subsets of the clubs.

5 These clubs differ from standard clubs in many ways, including

- The tempo is matched (square root relationship);
- The perceived force is matched (constant);
- The perceived length is matched (constant).

10 Further, the clubs are significantly longer than standard clubs (especially the woods), and contain substantial added weight. Also, this set of clubs intentionally does not include a 2-iron or 3-iron.

15 Other embodiments of the invention will be apparent to those skilled in the art from a consideration of the specification or practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with the true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

- 2 9. The method of claim 1, further comprising optimizing the lean angle of the clubs.
- 3
- 4 10. The method of claim 1, wherein the tempo is independent of club length.
- 5
- 6 11. The method of claim 1, wherein the tempo is a linear function of club length or of
- 7 club length plus arm length.
- 8
- 9 12. The method of claim 1, wherein the tempo is a power-law function of club length
- 0 or of club length plus arm length.
- 1
- 2 13. The method of claim 1, wherein the perceived force is independent of club length.
- 3
- 4 14. The method of claim 1, wherein the perceived force is a linear function of club
- 5 length or of club length plus arm length.
- 6
- 7 15. The method of claim 1, wherein the perceived force is a power-law function of
- 8 club length or of club length plus arm length.
- 9
- 0 16. The method of claim 1, wherein the perceived force is independent of club length
- 1 and the tempo is proportional to the square root of club length plus arm length.
- 2
- 3 17. The method of claim 1, further comprising designing a second golf club having at
- 4 least one different design parameter from the first club, wherein the same tempo
- 5 function and perceived force function apply to both clubs.
- 6
- 7 18. The method of claim 17, wherein the two golf clubs have a reduced difference in
- 8 perceived length.

- 1 19. The method of claim 18, wherein the perceived length is measured by
2 determining the radius of gyration of a club about a selected center point.
3
- 4 20. The method of claim 19, wherein the center point is selected by
5 having the golfer swing a test club to determine its perceived length;
6 having the golfer swing a comparison club one or more times while adding weight
7 to the comparison club at a selected point along the shaft until the golfer is
8 unable to distinguish the perceived lengths of the test club and the
9 comparison club; and
10 determining the center point around which the test club and the weighted
11 comparison club have identical radii of gyration.
12
- 13 21. The method of claim 1, comprising designing up to thirteen golf clubs all having
14 the same tempo and perceived force functions and reduced differences in
15 perceived lengths.
16
- 17 22. The method of claim 1, further comprising constructing the designed club using a
18 CAD/CAM system.
19
- 20 23. A method of determining a perceived center of gyration for a golfer, comprising
21 having the golfer swing a test club to determine its perceived length;
22 having the golfer swing a comparison club one or more times while adding weight
23 to the comparison club at a selected point along the shaft until the golfer is
24 unable to distinguish the perceived lengths of the test club and the
25 comparison club; and
26 determining the center point around which the test club and the weighted
27 comparison club have identical radii of gyration.
28
- 29 24. A method of constructing a matched set of golf clubs for a golfer, comprising

1 determining a perceived center of gyration according to the method of claim 23;
2 and
3 constructing a plurality of clubs having reduced variation in radius of gyration
4 with respect to the determined center point.
5

6 25. A matched set of golf clubs for a golfer, comprising
7 a plurality of golf clubs, wherein each club has a length and a target distance,
8 wherein a selected functional relationship exists over the plurality of clubs
9 between
10 the tempo when striking a ball with one of the clubs to produce the target
11 distance for that club, and
12 the length of that club.
13

14 26. The matched set of golf clubs of claim 25, wherein the tempo when striking a ball
15 with each of the clubs to produce that club's target distance is the same.
16

17 27. The matched set of golf clubs of claim 25, wherein the selected functional
18 relationship is a linear relationship.
19

20 28. The matched set of golf clubs of claim 25, wherein the selected functional
21 relationship is a polynomial relationship.
22

23 29. The matched set of golf clubs of claim 25, wherein the selected functional
24 relationship is a power-law relationship.
25

26 30. The matched set of golf clubs of claim 25, wherein a selected functional
27 relationship exists over the plurality of clubs between
28 the perceived force when striking a ball with one of the clubs to produce
29 the target distance for that club, and
30 the length of that club.

- 1
- 2 31. The matched set of golf clubs of claim 30, wherein the perceived force is
- 3 measured by determining the centripetal force exerted along the shaft of the club
- 4 at impact.
- 5
- 6 32. The matched set of golf clubs of claim 25, wherein the tempo is measured by
- 7 determining the speed of the golfer's hands at impact.
- 8
- 9 33. The matched set of golf clubs of claim 25, wherein the lean angle of the clubs is
- 10 optimized.
- 11
- 12 34. The matched set of golf clubs of claim 25, wherein the clubs have been designed
- 13 by a computer-aided design method, and wherein the club have been
- 14 manufactured by a computer-assisted manufacturing method.
- 15
- 16 35. A matched set of golf clubs for a golfer, comprising
- 17 a plurality of golf clubs, wherein each club has a length and a target distance,
- 18 wherein a selected functional relationship exists over the plurality of clubs
- 19 between
- 20 the perceived force when striking a ball with one of the clubs to produce
- 21 the target distance for that club, and
- 22 the length of that club.
- 23
- 24 36. A matched set of golf clubs for a golfer, comprising
- 25 a plurality of golf clubs, wherein each club has a length and a desired ball
- 26 trajectory,
- 27 wherein a selected functional relationship exists over the plurality of clubs
- 28 between
- 29 the tempo when striking a ball with one of the clubs to produce the desired
- 30 ball trajectory for that club, and

the length of that club.

37. The matched set of golf clubs of claim 36, wherein the tempo when striking a ball with each of the clubs to produce that club's desired ball trajectory is the same.
38. The matched set of golf clubs of claim 36, wherein the selected functional relationship is a linear relationship.
39. The matched set of golf clubs of claim 36, wherein the selected functional relationship is a polynomial relationship.
40. The matched set of golf clubs of claim 36, wherein the selected functional relationship is a power-law relationship.
41. The matched set of golf clubs of claim 36, wherein a selected functional relationship exists over the plurality of clubs between
the perceived force when striking a ball with one of the clubs to produce
the desired ball trajectory for that club, and
the length of that club.
42. The matched set of golf clubs of claim 41, wherein the perceived force is measured by determining the centripetal force applied along the shaft of the club at impact.
43. The matched set of golf clubs of claim 36, wherein the tempo is measured by determining the speed of the golfer's hands at impact.
44. The matched set of golf clubs of claim 36, wherein the lean angle of the clubs is optimized.

- 1 45. A matched set of golf clubs for a golfer, comprising
2 a plurality of golf clubs, wherein each club has a length and a desired ball
3 trajectory,
4 wherein a selected functional relationship exists over the plurality of clubs
5 between
6 the perceived force when striking a ball with one of the clubs to produce
7 the desired ball trajectory for that club, and
8 the length of that club.

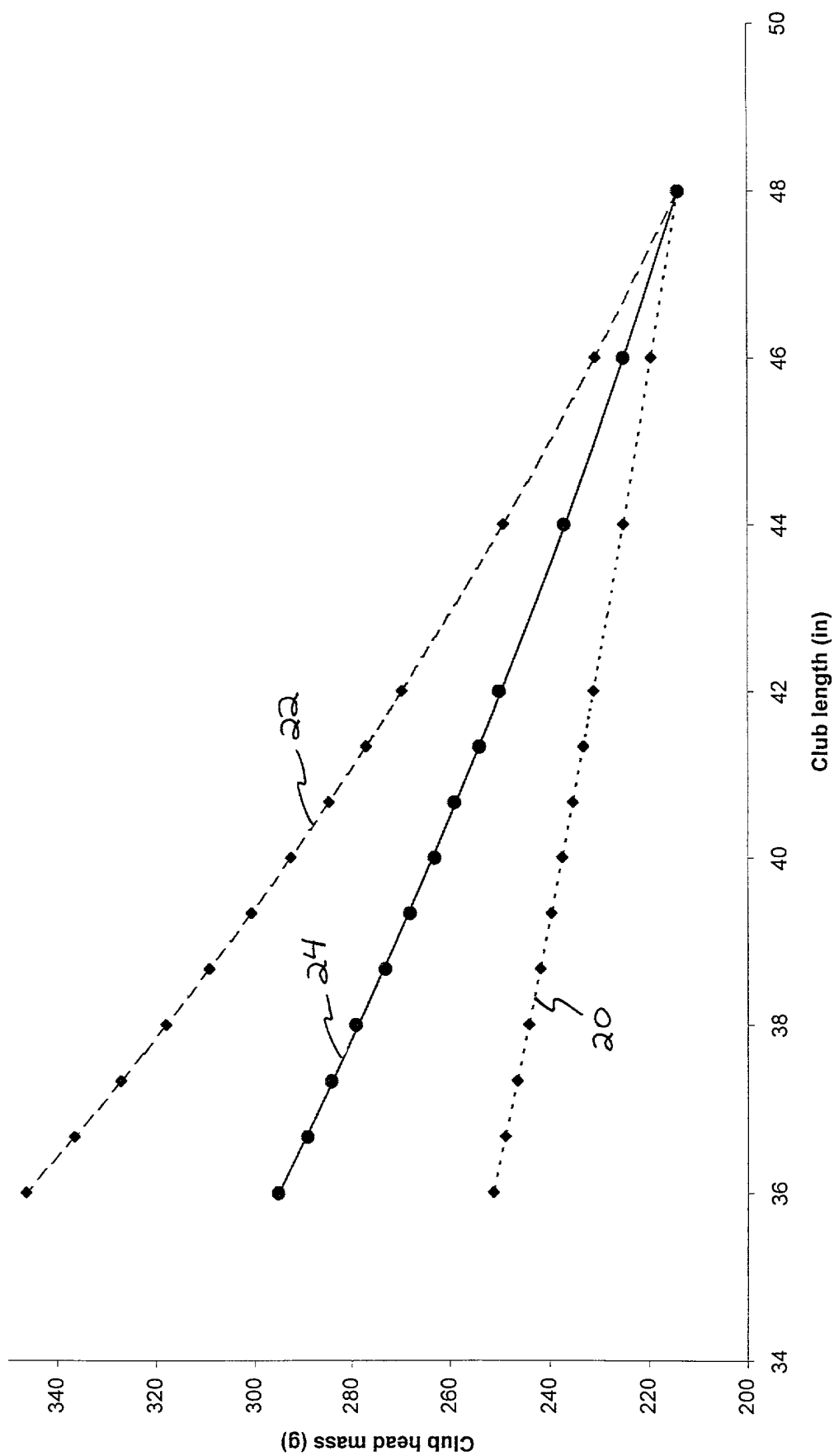
Abstract of the Disclosure

Methods of optimizing and matching golf clubs, and the clubs so matched. Clubs are selected to produce a desired relationship between hand speed at impact (tempo), and centripetal force on the hands at impact (perceived force). Clubs may also be selected to minimize and equate (or reduce variation in) the radius of gyration, as measured about a center point which is individually determined for each golfer.

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Figure 1



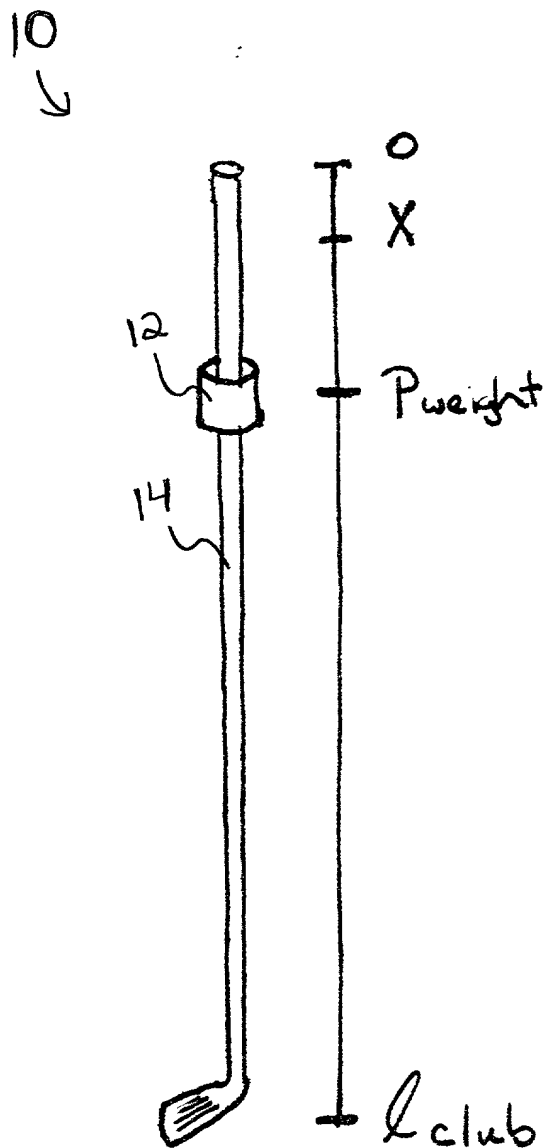


Figure 2

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

This declaration is original.

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SYSTEM FOR OPTIMIZATION OF GOLF CLUBS

the specification of which (I authorize Choate, Hall & Stewart to check one of the following, three choices, and fill in the blanks, if applicable):

 X is attached hereto.

 was filed on as Application Serial No. and amended on (if applicable).

 was filed as PCT international application No. , on and was amended under PCT Article 19 on (if applicable).

I hereby state that I have reviewed and understood the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledged the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):

Priority Claimed

<u> </u> (Number)	<u> </u> (Country)	<u> </u> (Day/Month/Year/Filed)	<u> </u> Yes	<u> </u> No
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<u> </u> (Number)	<u> </u> (Country)	<u> </u> (Day/Month/Year/Filed)	<u> </u> Yes	<u> </u> No
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I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of

America listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

_____	_____	_____
(Application Serial No.)	(filing date)	(status-patented, pending, abandoned)

_____	_____	_____
(Application Serial No.)	(filing date)	(status-patented, pending, abandoned)

PCT Applications designating the United States:

_____	_____	_____
(PCT Appl. No.)	(U.S.S.N.)	(status-patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United State Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

Full name of inventor: Howard B. Sosin

Inventor's signature: _____ Date: _____

Residence: 640 Sasco Hill Road, Fairfield CT 06430

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